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(71) Applicant: 000005120
Hitachi Cable Ltd.
1-6-1, Otemachi, Chiyoda-ku, Tokyo
(72) Inventor: Katsuyuki IMOTO
c/o Optoelectronic Systems Laboratory,
Hitachi Cable Ltd.,
5-1-1, Hitaka-cho, Hitachi City, Ibaraki Prefecture
(74) Agent: 100068021
Nobuo KINUYA,[1] Patent Attorney
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[1] Translator's note: The most likely reading is given for Japanese names not available in English.

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(54) [Title of the Invention]

Method and Device for Machining a Substrate of Nonmetallic Material

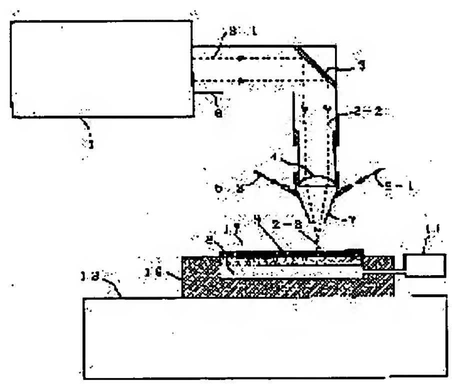
(57) [Summary]

[Problem]

To provide a method and device for machining a substrate of nonmetallic material, in which the nonmetallic-material substrate can be vacuum-held[2] firmly when cutting the nonmetallic-material substrate with a laser beam.

[Solution Means]

In a nonmetallic-material substrate machining method that produces a chip-form substrate by using laser beam 2-3 to cut nonmetallic-material substrate 8, nonmetallic-material substrate 8 is placed on porous plate 17, and laser beam 2-3 is used to cut while vacuum-holding nonmetallic-material substrate 8 on porous plate 17 by evacuating from below porous plate 8.[3]



[2] Translator's note: Here and hereinafter, also translatable as "vacuum-adsorbed."
[3] Translator's note: The Japanese patent reads "8" but it should be "17."

[Claims]

[Claim 1]

A method for machining a substrate of nonmetallic material, characterized in that, in a nonmetallic-material substrate machining method that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate, the nonmetallic-material substrate is placed on a porous plate that withstands a temperature of at least 500 °C, and the laser beam is used to cut while the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate.

[Claim 2]

A method for machining a substrate of nonmetallic material, characterized in that, in a nonmetallic-material substrate machining method that produces a chip-form substrate by using a laser beam to cut the nonmetallic-material substrate after which each chip is cut and removed, the nonmetallic-material substrate is placed on a porous plate, and the laser beam is used to cut while the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate; then a UV adhesive sheet is stuck to the cut nonmetallic-material substrate sheet, and the vacuum is broken, after which the nonmetallic-material substrate is separated from the porous plate with the UV adhesive sheet; and then the UV adhesive sheet is irradiated with UV light, thereby weakening its adhesive force and detaching each chip-form substrate.

[Claim 3]

A method for machining a substrate of nonmetallic material, characterized in that, in a nonmetallic-material substrate machining method that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate, [the method] is composed the following six processes: Process 1, in which the nonmetallic-material substrate is placed on a porous plate mounted on the transfer equipment, and the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate; Process 2, which involves multiple repetitions of [both] the process in which, while the aforementioned nonmetallic-material substrate is irradiated with the laser beam, the aforementioned transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the x-axis direction, thereby cutting and cracking the

nonmetallic-material substrate from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the y-axis direction; Process 3, which involves multiple repetitions of [both] the process in which the aforementioned nonmetallic-material substrate is rotated 90 °C by the aforementioned transfer equipment, and the nonmetallic-material substrate again is irradiated with the laser beam, during which time the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the y-axis direction, thereby cutting and cracking [it] from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the x-axis direction; Process 4, in which a UV adhesive sheet is stuck to the surface of the nonmetallic-material substrate that was cut and cracked into a grid in the aforementioned x-axis and y-axis directions; Process 5, in which the vacuum of the vacuum pump is broken, thereby separating the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transferred to the transport mechanism and transported; and Process 6,[4] in which the UV adhesive sheet is irradiated with UV light, thereby weakening the adhesive force of the adhesive sheet, which detaches the cut-and-cracked, chip-form substrates, after which they are retrieved.

[Claim 4]

The method for machining the substrate of nonmetallic material described in Claim 3, such that [the following two processes] are added: Process A, whereby, during Process 1 and Process 2, scribed lines are pre-engraved[5] in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path; and Process B, whereby, during Process 2 and Process 3, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[Claim 5]

The method for machining the substrate of nonmetallic material described in Claim 3, such that [the following process] is added: Process C, whereby, during Process 1 and

[4] Translator's note: The Japanese patent reads "Process 5."
[5] Translator's note: Also translatable as "pre-marked."

Process 2, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction and the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[Claim 6]

The method for machining the substrate of nonmetallic material described in Claim 4, such that it is composed of Process D, in which Process A and Process 2 are performed in conjunction, and Process E, in which Process B and Process 3 are performed successively.

[Claim 7]

The method for machining the substrate of nonmetallic material described in any one of Claims 1–6, such that [one of the following] laser beams is used: a CO_2 laser beam, a CO laser beam, a YAG laser beam, a laser beam that [operates at] a harmonic of the YAG laser beam or an excimer laser beam.

[Claim 8]

The method for machining the substrate of nonmetallic material described in any one of Claims 1–7, such that an assist gas is flowed along the laser beam.

[Claim 9]

The method for machining the substrate of nonmetallic material described in any one of Claims 1–8, such that a long-and-thin laser beam (width: W, length: L) is used to irradiate the nonmetallic-material substrate with the laser beam.

[Claim 10]

The method for machining the substrate of nonmetallic material described in any one of Claims 1–9, such that the nonmetallic-material substrate is machined while cooling the side immediately behind the laser beam irradiated onto the nonmetallic-material substrate.

[Claim 11]

A device for machining a substrate of nonmetallic material, characterized in that, in a nonmetallic-material substrate machining device that produces a chip-form substrate by using a laser beam to cut the nonmetallic-material substrate, a porous plate on which is placed the nonmetallic-material substrate cut into chips is placed on the irradiated transfer equipment, a evacuation hole is formed in the underside of the porous plate, and a vacuum pump is connected to this evacuation hole.

[Claim 12]

A device for machining a substrate of nonmetallic material, characterized in that,

in a nonmetallic-material substrate machining device that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate,

[it] is equipped with

a first means such that a nonmetallic-material substrate is placed on a porous plate mounted on the transfer equipment, and the nonmetallic material wafer is vacuum-held on the porous plate by evacuating from below the porous plate,

a second means [that involves] multiple repetitions of [both] the process in which, while the nonmetallic-material substrate is irradiated with the laser beam, the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the x-axis direction, thereby cutting and cracking the nonmetallic-material substrate from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the y-axis direction,

a third means [that involves] multiple repetitions of [both] the process in which the aforementioned nonmetallic-material substrate is rotated 90 °C by the aforementioned transfer equipment, and the nonmetallic-material substrate again is irradiated with the laser beam, during which time the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the y-axis direction, thereby cutting and cracking [it] from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the x-axis direction,

a fourth means such that a UV adhesive sheet is stuck to the surface of the nonmetallic-material substrate that was cut and cracked into a grid in the aforementioned x-axis and y-axis directions,

a fifth means such that the vacuum of the vacuum pump is broken, thereby separating the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transferred to the transport mechanism and transported,

and a sixth means such that the UV adhesive sheet is irradiated with UV light, thereby weakening the adhesive force of the adhesive sheet, which detaches the cut-and-cracked, chip-form substrates, after which they are retrieved.

[Claim 13]

The device for machining the substrate of nonmetallic material described in Claim 12, such that [the following two] means are added: means A, whereby, during the first means and the second means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path; and means B, whereby, during the second means and the third means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[Claim 14]

The device for machining the substrate of nonmetallic material described in Claim 13, such that [the following means] is added: means C, whereby, during the first means and the second means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction and the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[Claim 15]

The device for machining the substrate of nonmetallic material described in Claim 14, that is equipped with a means whereby means A and the second means are performed in conjunction, and a means whereby means B and the third means are performed successively.

[Claim 16]

The device for machining the substrate of nonmetallic material described in any one of Claims 11–15, such that [one of the following] laser beams is used: a CO_2 laser beam, a CO laser beam, a YAG laser beam, a laser beam that [operates at] a harmonic of the YAG laser beam or an excimer laser beam.

[Claim 17]

The device for machining the substrate of nonmetallic material described in any one of Claims 11–16, such that a ceramic or metal porous plate is used as the porous plate.

[Claim 18]

The device for machining the substrate of nonmetallic material described in any one of Claims 11–17, such that an assist gas is flowed along the laser beam.

[Claim 19]

The device for machining the substrate of nonmetallic material described in any one of Claims 11–18, such that a long-and-thin laser beam (width: W, length: L) is used to irradiate the nonmetallic-material substrate with the laser beam.

[Claim 20]

The device for machining the substrate of nonmetallic material described in any one of Claims 11–19, such that the nonmetallic-material substrate is machined while cooling the side immediately behind the laser beam irradiated onto the nonmetallic-material substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a method and device for machining a nonmetallic-material substrate, to produce chips by using a laser beam to cut the nonmetallic-material substrate.

[0002]

[Prior Art]

There is increased demand for a technique for precisely subdividing into minute chips a nonmetallic substrate, such as a glass substrate, a ceramic substrate, a semiconductor (e.g., Si, GaAs, InP) substrate with insulating film, a sapphire substrate, and a crystal substrate of $LiNbO_3$, $LiTaO_5$, etc.

[0003]

There is particularly strong demand for technology for subdividing without chipping, into a size of several mm square, by means of a dry process, without generating particles during division.

[0004]

In response to this demand, techniques that use a CO_2 laser beam to cut without contact and by means of a dry process are attracting attention.

[0005]

Drawing 9 is a schematic diagram showing a conventional device for machining a nonmetallic-material substrate by using a CO_2 laser beam.

[0006]

CO_2 laser beam (i.e., collimated beam) 2-1 emitted from CO_2 laser oscillator 1 propagates within hood 6 and is propagated as shown by arrow 2-2 after being bent at a right angle by totally reflective mirror 3, after which it enters focusing[6] lens 4, where beam 2-3 [7] is focused as shown by the arrow[s]. This beam 2-3 is irradiated onto nonmetallic-material substrate 8, via conical gas nozzle tube 7. Also, assist gas 5-1, 5-2 is sprayed onto the aforementioned nonmetallic [8] material substrate 8, via the aforementioned gas nozzle tube 7.

[0007]

Nonmetallic-material substrate 8 is vacuum-held on worktable 9 on XYZθ transfer equipment (or XYθ transfer equipment) 12.

[0008]

10 are vacuum suction holes, and 11 is the vacuum pump for vacuum-holding the rear surface of substrate 8 to worktable 9, via the aforementioned vacuum suction holes 10.

[0009]

CO_2 laser beam 2-3 is used to irradiate a nonmetallic[9] material substrate 8 from one end to the other end, while moving in the x (or y) direction. As a result, substrate 8 is cracked by the thermal stress, and substrate 8 is subdivided by propagating these cracks.

[00010]

Drawing 10 is a schematic diagram showing the method [used] to obtain chips 13-1 and 13-2, by subdividing into a grid shape nonmetallic-material substrate 8.

[6] Translator's note: Also translatable as "condensing."
[7] Translator's note: In section [0042] of the Japanese patent, this beam is 2-2. It is unclear which arrow(s) is/are intended.
[8] Translator's note: The Japanese patent reads "metallic."
[9] Translator's note: The Japanese patent reads "metallic."

[00011]

[In this] method, first, cracks 15-1, 15-2, 15-3,..., 15-7 are produced successively, while moving nonmetallic-material substrate 8 in the y-direction of arrow 14-2. Next, substrate 8 is rotated 90°, after which board 8 is moved in the direction of arrow 14-1, during which time cracks are produced as [indicated by] 16-1, 16-2, 16-3, 16-4,..., which yields chips 13-1, 13-2,....

[00012]

Vacuum suction holes 10-1, 10-2, 10-3,..., 10-64 are provided beneath respective chips 13-1, 13-2, 13-3....

[00013]

Furthermore, when the second-harmonic light or third-harmonic light of a YAG laser is used instead of a CO_2 laser, cutting is performed by means of the same method.

[00014]

[Problems that the Invention Is to Solve]

However, the following problems remain in the conventional method and device used to cut by means of a laser.

[00015]

(1) When the chip size is several mm square or smaller, the respective vacuum suction holes 10 provided on the backs of the chips to be subdivided also must have a diameter of at most several mm. The reason is that, to prevent the respective subdivided chips from blowing off during the cutting process, they must be vacuum-held securely. However, when the diameter is 1 mm or less, the vacuum suction decreases considerably, so vacuum suction is difficult. Also, it is difficult to provide many of the aforementioned vacuum suction holes 10 on the worktable at 1-mm intervals, from the standpoint of mechanical dimensional precision (worktable flatness).

[00016]

(2) Because of the weakness of the aforementioned vacuum-holding force,[10] gaps occur in the crack regions during the cutting process. So, when producing cracks orthogonally in a grid, it is difficult to produce cracks, and discontinuous[11] cracks occur at the intersections of the grid, so it is difficult to subdivide, with high dimensional accuracy, square (or rectangular) chips. Also, worst-case problems include the flying off of chips during the cutting process.

[00017]

(3) It is difficult to retrieve and transport with good alignment the respective chips that were subdivided during the cutting process.

[00018]

Therefore, the purpose of the present invention is to solve the aforementioned problems and to provide a method and device for machining a nonmetallic-material substrate, such that the nonmetallic-material substrate can be vacuum-held securely when cutting the nonmetallic-material substrate with a laser beam.

[00019]

[Means of Solving the Problems]

To achieve the purpose aforementioned, the invention of Claim 1 is a method for machining a substrate of nonmetallic material, such that, in a nonmetallic-material substrate machining method that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate, the nonmetallic-material substrate is placed on a porous plate that withstands a temperature of at least 500 °C, and the laser beam is used to cut while the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate.

[10] Translator's note: Also translatable as "vacuum adsorptivity."
[11] Translator's note: The Japanese contains a typo here.

[00020]

The invention of Claim 2 is a method for machining a substrate of nonmetallic material, such that, in a nonmetallic-material substrate machining method that produces a chip-form substrate by using a laser beam to cut the nonmetallic-material substrate after which each chip is cut and removed, the nonmetallic-material substrate is placed on a porous plate, and the laser beam is used to cut while the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate; then a UV adhesive sheet is stuck to the cut nonmetallic-material substrate sheet, and the vacuum is broken, after which the nonmetallic-material substrate is separated from the porous plate with the UV adhesive sheet; and then the UV adhesive sheet is irradiated with UV light, thereby weakening its adhesive force and detaching each chip-form substrate.

[00021]

The invention of Claim 3 is a method for machining a substrate of nonmetallic material, that, in a nonmetallic-material substrate machining method that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate, is composed the following six processes: Process 1, in which the nonmetallic-material substrate is placed on a porous plate mounted on the transfer equipment, and the nonmetallic-material substrate is vacuum-held on the porous plate by evacuating from below the porous plate; Process 2, which involves multiple repetitions of [both] the process in which, while the aforementioned nonmetallic-material substrate is irradiated with the laser beam, the aforementioned transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the x-axis direction, thereby cutting and cracking the nonmetallic-material substrate from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the y-axis direction; Process 3, which involves multiple repetitions of [both] the process in which the aforementioned nonmetallic-material substrate is rotated 90 °C by the aforementioned transfer equipment, and the nonmetallic-material substrate again is irradiated with the laser beam, during which time the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the y-axis direction, thereby cutting and cracking [it] from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the x-axis direction; Process 4, in which a UV adhesive sheet is stuck to the surface of the nonmetallic-material substrate that was cut and cracked into a grid in the aforementioned

x-axis and y-axis directions; Process 5, in which the vacuum of the vacuum pump is broken, thereby separating the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transferred to the transport mechanism and transported; and Process 6, in which the UV adhesive sheet is irradiated with UV light, thereby weakening the adhesive force of the adhesive sheet, which detaches the cut-and-cracked, chip-form substrates, after which they are retrieved.

[00022]

The invention of Claim 4 is the method for machining the substrate of nonmetallic material described in Claim 3, such that [the following two processes] are added: Process A, whereby, during Process 1 and Process 2, scribed lines are pre-engraved in advance in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path; and Process B, whereby, during Process 2 and Process 3, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[00023]

The invention of Claim 5 is the method for machining the substrate of nonmetallic material described in Claim 3, such that [the following process] is added: Process C, whereby, during Process 1 and Process 2, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction and the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[00024]

The invention of Claim 6 is the method for machining the substrate of nonmetallic material described in Claim 4, which is composed of Process D, in which Process A and Process 2 are performed in conjunction, and Process E, in which Process B and Process 3 are performed successively.

[00025]

The invention of Claim 7 is the method for machining the substrate of nonmetallic material described in any one of Claims 1–6, such that [one of the following] laser beams is used: a CO_2 laser beam, a CO laser beam, a YAG laser beam, a laser beam that [operates at] a harmonic of the YAG laser beam or an excimer laser beam.

[00026]

The invention of Claim 8 is the method for machining the substrate of nonmetallic material described in any one of Claims 1–7, such that an assist gas is flowed along the laser beam.

[00027]

The invention of Claim 9 is the method for machining the substrate of nonmetallic material described in any one of Claims 1–8, such that a long-and-thin laser beam (width: W, length: L) is used to irradiate the nonmetallic-material substrate with the laser beam.

[00028]

The invention of Claim 10 is the method for machining the substrate of nonmetallic material described in any one of Claims 1–9, such that the nonmetallic-material substrate is machined while cooling the side immediately behind the laser beam irradiated onto the nonmetallic-material substrate.

[00029]

The invention of Claim 11 is a device for machining the substrate of nonmetallic material, such that, in a nonmetallic-material substrate machining device that produces a chip-form substrate by using a laser beam to cut the nonmetallic-material substrate, a porous plate on which is placed the nonmetallic-material substrate cut into chips is placed on the irradiated transfer equipment, a evacuation hole is formed in the underside of the porous plate, and a vacuum pump is connected to this evacuation hole.

[00030]

The invention of Claim 12 is a device for machining the substrate of nonmetallic material, that,

in a nonmetallic-material substrate machining device that produces chip-form substrates by using a laser beam to cut the nonmetallic-material substrate,

is equipped with

a first means such that a nonmetallic-material substrate is placed on a porous plate mounted on the transfer equipment, and the nonmetallic material wafer is vacuum-held on the porous plate by evacuating from below the porous plate,

a second means [that involves] multiple repetitions of [both] the process in which, while the nonmetallic-material substrate is irradiated with the laser beam, the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the x-axis direction, thereby cutting and cracking the nonmetallic-material substrate from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the y-axis direction,

a third means [that involves] multiple repetitions of [both] the process in which the aforementioned nonmetallic-material substrate is rotated 90 °C by the aforementioned transfer equipment, and the nonmetallic-material substrate again is irradiated with the laser beam, during which time the transfer equipment is operated to move the nonmetallic-material substrate at the desired speed in the y-axis direction, thereby cutting and cracking [it] from one end to the other end, as well as the process in which [it] is again cut and cracked in the x-axis direction at the desired pitch in the x-axis direction,

a fourth means such that a UV adhesive sheet is stuck to the surface of the nonmetallic-material substrate that was cut and cracked into a grid in the aforementioned x-axis and y-axis directions,

a fifth means such that the vacuum of the vacuum pump is broken, thereby separating the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transferred to the transport mechanism and transported,

and a sixth means such that the UV adhesive sheet is irradiated with UV light, thereby weakening the adhesive force of the adhesive sheet, which detaches the cut-and-cracked, chip-form substrates, after which they are retrieved.

[00031]

The invention of Claim 13 is the device for machining the substrate of nonmetallic material described in Claim 12, such that [the following two] means are added: means A, whereby, during the first means and the second means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path; and means B, whereby, during the second means and the third means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[00032]

The invention of Claim 14 is the device for machining the substrate of nonmetallic material described in Claim 13, such that [the following means] is added: means C, whereby, during the first means and the second means, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x-axis direction and the y-axis direction of the nonmetallic-material substrate, along the laser beam irradiation path.

[00033]

The invention of Claim 15 is the device for machining the substrate of nonmetallic material described in Claim 14, that is equipped with a means whereby means A and the second means are performed in conjunction, and a means whereby means B and the third means are performed successively.

[00034]

The invention of Claim 16 is the device for machining the substrate of nonmetallic material described in any one of Claims 11–15, such that [one of the following] laser beams is used: a CO_2 laser beam, a CO laser beam, a YAG laser beam, a laser beam that [operates at] a harmonic of the YAG laser beam or an excimer laser beam.

[00035]

The invention of Claim 17 is the device for machining the substrate of nonmetallic material described in any one of Claims 11–16, such that a ceramic or metal porous plate is used as the porous plate.

[00036]

The invention of Claim 18 is the device for machining the substrate of nonmetallic material described in any one of Claims 11–17, such that an assist gas is flowed along the laser beam.

[00037]

The invention of Claim 19 is the device for machining the substrate of nonmetallic material described in any one of Claims 11–18, such that a long-and-thin laser beam (width: W, length: L) is used to irradiate the nonmetallic-material substrate with the laser beam.

[00038]

The invention of Claim 20 is the device for machining the substrate of nonmetallic material described in any one of Claims 11–19, such that the nonmetallic-material substrate is machined while cooling the side immediately behind the laser beam irradiated onto the nonmetallic-material substrate.

[00039]

[Preferred Embodiment of the Invention]

Next, preferred embodiments of the present invention will be discussed in detail, with reference to the appended drawings.

[00040]

First, Drawing 5 will be used to explain the configuration of the cutting device for the nonmetallic-material substrate.

[00041]

In this Drawing 5, [components labeled] with symbols identical to those explained in Drawing 9 have the same functions.

[00042]

That is, CO_2 laser beam (collimated beam) 2-1 emitted from CO_2 laser oscillator 1 propagates within hood 6, after which it is bent at a right angle by totally reflective mirror 3 and propagates as shown by the arrow. [It then] it enters focusing lens 4, where beam 2-2[12] is focused as shown by the arrow[s]. This beam 2-3 is irradiated onto nonmetallic-material substrate 8, via conical gas nozzle tube 7. Also, assist gas 5-1, 5-2 is sprayed onto the aforementioned nonmetallic[13] material substrate 8, via the aforementioned gas nozzle tube 7.

[00043]

Nonmetallic-material substrate 8 is vacuum-held on worktable 19 on XYZθ transfer equipment (or XYθ transfer equipment) 12.

[00044]

The [essence] of the presence invention is the improvement of this worktable 19.

[12] Translator's note: In section [0006] of the Japanese patent, this beam is 2-3. It is unclear which arrow(s) is/are intended.
[13] Translator's note: The Japanese patent reads "metallic."

[00045]

That is, worktable 19 is configured such that porous plate 17 that withstands a temperature of at least 500 °C is installed; nonmetallic-material substrate 8 is placed on this porous plate 17; evacuation hole 18 is provided in worktable 19 below porous plate 17; vacuum pump 11 is connected to this evacuation hole 18; and by using vacuum pump 11 to evacuate this evacuation hole 18, the bottom surface of nonmetallic-material substrate 8 is vacuumed via porous plate 17 and evacuation hole 18, thereby sucking it onto porous plate 17.

[00046]

In the cutting process that uses CO_2 laser beam 2-3, the instantaneous temperature rise on the rear surface of nonmetallic-material substrate 8 is at most 500 °C, so a metal or ceramic can be used safely as the material of porous plate 17.

[00047]

This porous plate 17 is structured so as to have many pores on the order of several μm to 100 μm, so even when [the substrate] is subdivided into chips [measuring] approximately 1 mm square by means of cut cracks, it is possible to hold nonmetallic-material substrate 8 on porous plate 17 by sufficiently vacuum-holding it.

[00048]

Also, the surface of porous plate 17 is much smoother than the surface of worktable 9, in which conventional vacuum suction holes 10 are provided. Therefore, it is possible to vacuum-hold sufficiently even if the rear surface of nonmetallic-material substrate 8 is not smooth.

[00049]

The first embodiment of the nonmetallic-material substrate cutting method of the present invention is shown in Drawing 1. This cutting method is composed of six processes.

[00050]

Usable nonmetallic-material substrates include glass, a ceramic, a semiconductor (e.g., Si, GaAs, InP) with insulating film, and a crystal (e.g., sapphire, $LiNbO_3$, $LiTaO_5$). In this method, this nonmetallic-material substrate is subdivided by cutting it into chips [with sizes ranging from] small (on the order of a submillimeter square) to large (several mm square or several tens of mm square).

[00051]

Process 1: First, in Process 1 (S1),[14] the nonmetallic-material substrate is placed on a porous plate mounted on the transfer equipment that enables movement in the x, y, z, and θ directions, by means of an electric drive. This porous plate can be made of metal, ceramic, etc. The porous plate is a plate having multiple pores [measuring] from several μm to approximately 100 μm. If a mechanism for evacuating from below this porous plate is provided, the nonmetallic-material substrate is vacuum-held on[15] the porous plate, so it will not be blown off by the spraying of the assist gas,[16] even during cutting. The subdivided minute chips (submillimeter squares) also will be held tightly to the porous plate, with sufficient vacuum-holding.

[00052]

Process 2: Next, in Process 2 (S2), while the assist gas is sprayed onto the vacuum-held nonmetallic-material substrate, and while the transfer equipment is moved to move the nonmetallic material on the transfer equipment at the desired speed in the x direction, the nonmetallic-material substrate is irradiated, from one end to the other end, with the CO_2 laser beam. This produces a crack from one end of the nonmetallic-material substrate and propagates it to the other end. [By means of the] same operation, another cut and crack are produced in the x direction in the nonmetallic-material substrate, at the desired pitch in the y direction. Furthermore, by repeating multiple times the aforementioned operation, cuts and cracks are formed, from one end of the substrate to the other end, at the desired pitch, in the y direction in the nonmetallic-material substrate.

[14] Translator's note: The literal translation is "Process," although "S" apparently indicates "Step."
[15] Translator's note: The Japanese patent reads "is evacuated onto."
[16] Translator's note: The Japanese patent contains a typo for this word.

[00053]

Process 3: Next, in Process 3 (S3), the aforementioned substrate is rotated 90 °C by the transfer equipment, and while again spraying the assist gas, the transfer equipment is operated while using the CO_2 laser beam to irradiate the nonmetallic-material substrate, thereby moving the nonmetallic-material substrate at the desired speed in the y direction, which produces cuts and cracks from one end to the other end. The process [whereby] cuts and cracks are again produced in the y direction, at a given pitch in the x direction, is repeated multiple times.

[00054]

By means of the aforementioned operations, an x-y grid of cuts and cracks is produced in the nonmetallic-material substrate.

[00055]

In the aforementioned Processes 2 and 3, a CO_2 laser (wavelength: 10.6 μm) is used as the laser oscillator. In addition to this [laser], however, a CO laser, YAG laser, a laser that [operates at] a harmonic of the YAG laser beam, an excimer laser, etc., can be used as the light source with a wavelength easily absorbed by the nonmetallic-material substrate.

[00056]

Next will be explained the process in which the multiple minute chips subdivided in Process 3 are retrieved as a batch, without disturbing their arrangement, and finally each chip is retrieved separately.

[00057]

Process 4: First, in Process 4 (S4), a UV adhesive sheet is stuck to the substrate surface, with the nonmetallic-material substrate cut and cracked in Process 3 vacuum-held. Dicing tape made by Lintec Corporation, for example, is used for this UV adhesive sheet. The adhesive layer is formed on the application layer of a polyolefin sheet, so this tape can be attached to the aforementioned substrate surface.

[00058]

Process 5: Next, in Process 5 (S5), the vacuum of the vacuum pump is broken, thereby separating the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transferred to the transport mechanism and transported. Each chip is stuck to the UV adhesive sheet, so they do not fall off and scatter during transport.

[00059]

Process 6: Finally, in Process 6 (S6), the other side of the UV adhesive sheet (i.e., the side to which the nonmetallic-material substrate is not attached) is irradiated with UV light. As a result of this UV light irradiation, the adhesive force of the aforementioned UV adhesive sheet decreases sharply. (For example, an adhesive force of 300 mN / 25 mm□ drops to an adhesive force of 50 mN / 25 mm□.) Therefore, each cut-and-cracked chip is detached and can be retrieved easily from the aforementioned UV adhesive sheet. The electrical or optical [properties] of each chip are evaluated, after which it can be mounted in a device or equipment.[17]

[00060]

As aforementioned, during the laser cutting process, chips do not blow off and unnecessary gaps do not occur in the crack region. Also, even in the case of extremely minute chips, it is possible to maintain their position by adequately vacuum-holding them. Furthermore, when cut chips are retrieved, they do not detach separately, so the chips are easily located, etc., on the substrate. Therefore, it is possible to retrieve them from the process equipment in the cut-and-cracked state. Finally, it is possible to test and inspect each chip as is, before removing each chip. Also, it also is possible to test and inspect after removing each chip.

[17] Translator's note: The grammar of the Japanese sentence is ambiguous. This seems to be the meaning intended by the author.

[00061]

The second embodiment of the nonmetallic-material substrate cutting method of the present invention is shown in Drawing 2.

[00062]

In the second embodiment, Process A is provided between Process 1 and Process 2 of the first embodiment shown in Drawing 1, and Process B is provided between Process 2 and Process 3.

[00063]

In the aforementioned Process A, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path.

[00064]

Also, in Process B, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path.

[00065]

Various convention methods can be used as the aforementioned scribed line engraving method. Examples include a method of forming the scribed line by irradiating with a laser (e.g., a YAG laser, excimer laser), a method of forming the scribed line by using a diamond or super-hard[18] cutter, a method of forming the scribed line by using an ultrasonic vibrator, and a method of forming the scribed line by using a metal file, needle,[19] etc., with a sharp edge.

[18] Translator's note: Also translatable as "carbide."
[19] Translator's note: Also translatable as "hook."

[00066]

If a scribed line is drawn in advance along the path of the laser beam in this manner, it is possible to improve the crack propagation, crack linearity, intersection orthogonality, etc.

[00067]

The third embodiment of the nonmetallic-material substrate cutting method of the present invention is shown in Drawing 3.

[00068]

In the third embodiment, Process C is provided between Process 1 and Process 2 of the first embodiment shown in Drawing 1.

[00069]

In this Process C, scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x direction and y direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path.

[00070]

The fourth embodiment of the nonmetallic-material substrate cutting method of the present invention is shown in Drawing 4.

[00071]

The fourth embodiment includes Process D, in which Process A and Process 2 of the second embodiment shown in Drawing 2 are performed in conjunction; and Process E, in which Process B and Process 3 are performed in conjunction.

[00072]

A concrete example of the method used to process the nonmetallic-material substrate of the present invention is shown in Drawing 6.

[00073]

This machining method presents a concrete example of Process D of the fourth embodiment explained in Drawing 4.

[00074]

That is, in this method, cutting is performed as cracks are produced by irradiating a CO_2 laser beam along the scribed line, while engraving a scribed line along the path of the CO_2 laser beam.

[00075]

This method is such that, [along] scribed line 20, cracks are propagated and cutting is performed [as follows]: In this example, scribed line engraving part 22, in which tip 21 is composed of a rotary diamond cutter, is provided in advance of the CO_2 laser beam. While scribed line 20 is engraved, cracks are produced later by irradiating along the aforementioned scribed line 20 with CO_2 laser beam 2-3. Cutting is performed by propagating the cracks.

[00076]

Drawing 7 shows an embodiment in which the scribed line is pre-engraved on nonmetallic-material substrate 8.

[00077]

The scribed line may be engraved as indicated by 20-9, 20-10, 20-11, 20-12,..., in the vicinity of grid intersections, in the following manners: The scribed line is engraved as [indicated] by 20-5, 20-6,... (or 20-1, 20-2,...) at one end 23-1 (or 23-3) of nonmetallic-material substrate 8; or the scribed line is engraved as [indicated] by 20-9, 20-10,... (or

20-11, 20-11,...)[20] at the other end 23-2 (or 23-4); or a continuous scribe line is pre-engraved as indicated by 20-7, 20-8,... (or 20-3, 20-4,...), from one end 23-1 (or 23-3) to the other end 23-2 (or 23-4).

[00078]

In Drawing 8, the aforementioned nonmetallic-material substrate of the present invention, which was cut and cracked by means of the device in Drawing 5, is removed from porous plate 17, after which nonmetallic-material substrate 8 with adhesive sheet 24 is transported. The adhesive force of the adhesive layer is weakened by irradiating UV light 25a from UV light source 25, from behind the aforementioned UV adhesive sheet 24. Each chip 13-1, 13-2,..., 13-N is detached and retrieved from UV adhesive sheet 24.

[00079]

Furthermore, electric circuits (e.g., an IC, LSI), elements (e.g., resistors, inductors, capacitors), and electric wiring patterns, or optical circuits and optical wiring patterns may be formed in the substrate or on the front and back of nonmetallic-material substrate 8 used in the present invention. Also, the laser-irradiated surface may be either the front or back of the aforementioned nonmetallic-material substrate. Moreover, the nonmetallic-material substrate may have any shape (e.g., rectangular, circular, elliptical). The irradiation shape of laser beam 2-3 on nonmetallic-material substrate 8 preferably is a linear beam, elliptical beam, etc., with a width of at most 1 mm and a length of at least 10 mm. However, it also may be an almost circular beam. Also, the rear of the laser beam irradiation area on nonmetallic-material substrate 8 may be locally cooled rapidly. In the preferable rapid-cooling method, a refrigerant gas is sprayed.

[20] Translator's note: The Japanese patent reads "20-11, 20-11,..." but it probably should be "20-11, 20-12,...."

[00080]

[Effects of the Invention]

In short, as aforementioned, the present invention has the following effects:

[00081]

(1) Because the entire substrate back is uniformly and very securely vacuum-held, the cutting dimensional precision does not drop during minute chip cutting, even if cut chips are blown off[21] by the assist gas and gaps occur between chips.

[00082]

(2) After cutting is completed, the cut substrate can be transported to another location with its shape maintained as is (i.e., the UV adhesive sheet is stuck to the substrate surface, so that each chip does not scatter). The electrical properties or optical properties of each chip on the transported cut substrate also can be evaluated while the chips remain attached. It also is possible to evaluate as aforementioned the electrical or optical properties, by detaching each chip by using a UV light source to irradiate the aforementioned UV adhesive sheet.

[00083]

(3) The porous plate has an extremely smooth surface, so even minute, mm-size cut chips do not blow off during the cutting process, so it is possible to vacuum-hold [them] on the porous plate.

[00084]

(4) The total throughput time can be shortened, because it is possible to transport the entire cut substrate after removing it from the machining equipment. That is, after cutting, it is possible to considerably shorten the time from that [required] when removing individual chips from the machining equipment.

[00085]

(5) Also, it is possible to remove the entire cut substrate from the machining equipment, to inspect surface patterns of the chips on this substrate and evaluate the electrical or optical properties, and then to pick out only the non-defective parts. Therefore, even after the aforementioned processes, the time can be shortened considerably, which effectively enables low-cost chip production.

[00086]

(6) A porous plate is used, so during the cutting of chips of any size, one porous plate can be used for all applications, which reduces the manufacturing equipment cost and the estimated cost.[22]

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[21] Translator's note: The Japanese verb meaning "blown off" contains a typo.
[22] Translator's note: The Japanese seems to be a typo for the homophone meaning "capital cost."

[Brief Explanation of the Drawings]

Drawing 1 shows the first embodiment of the machining method of the present invention.

Drawing 2 shows the second embodiment of the machining method of the present invention.

Drawing 3 shows the third embodiment of the machining method of the present invention.

Drawing 4 shows the fourth embodiment of the machining method of the present invention.

Drawing 5 shows an embodiment of the machining device of the present invention.

Drawing 6 is a schematic perspective view showing a concrete example of Process D of the fourth embodiment of the present invention.

Drawing 7 is diagram showing an example in which scribed lines are pre-etched on the nonmetallic-material substrate [produced] by means of the machining method of the present invention.

Drawing 8 is a diagram showing the method of holding the cut nonmetallic-material substrate of the present invention, the transport means, and the chip detachment method.

Drawing 9 is a diagram showing the conventional machining device.

Drawing 10 is a diagram showing the conventional machining method.

[Explanation of Symbols]

2-3 Laser beam
8 Nonmetallic-material substrate
11 Vacuum pump
17 Porous plate
18 Evacuation hole
19 Transfer device[23]

[23] Translator's note: Translated as per the Japanese, but 12 is the transfer device and 19 is the worktable.

[Drawing 1]

The process in which a nonmetallic-material substrate is placed on a porous plate mounted on transfer equipment, and the porous plate is evacuated from below, thereby vacuum-holding the nonmetallic-material substrate on the porous plate.	← S1 (Process 1)
↓	
The process in which, while an assist gas is sprayed onto the nonmetallic-material substrate, a CO_2 laser beam is used to irradiate the nonmetallic-material substrate. Meanwhile, the transfer equipment is activated to move the nonmetallic-material substrate at the desired speed in the x direction, thereby producing cuts and cracks from one end to the other. [Also,] the process in which the process that produces cuts and cracks in the x direction is repeated multiple times, at the desired pitch in the y direction.	← S2 (Process 2)
↓	
The process in which, the aforementioned nonmetallic-material substrate is rotated 90° on the transfer equipment, after which the nonmetallic-material substrate is re-irradiated with the CO_2 laser beam while spraying the assist gas. Meanwhile, the transfer equipment is activated[24] to move the nonmetallic-material substrate at the desired speed in the y direction, thereby producing cuts and cracks from one end to the other. [Also,] the process in which the process that produces cuts and cracks in the y direction is repeated multiple times, at the desired pitch in the x direction.	← S3 (Process 3)
↓	
The process in which a UV adhesive sheet is stuck to the surface of the nonmetallic-material substrate in which a grid of cuts and cracks in the aforementioned x and y directions.	← S4 (Process 4)
↓	
The process in which the vacuum of the vacuum pump is broken, thereby detaching the nonmetallic-material substrate with the UV adhesive sheet from the porous plate, after which it is transported.	← S5 (Process 5)
↓	
The UV adhesive sheet is irradiated with UV light to weaken the adhesive force, thereby detaching the substrate of cut-and-cracked chips, after which [they] are removed.	← S6 (Process 6)

[24] Translator's note: The Japanese word contains a typo.

[Drawing 2]

Process 1 ← S1

↓

The process in which scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path. ← SA (Process A)

↓

Process 2 ← S2

↓

The process in which scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the y direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path. ← SB (Process B)

↓

Process 3 ← S3

↓

Process 4 ← S4

↓

Process 5 ← S5

↓

Process 6 ← S6

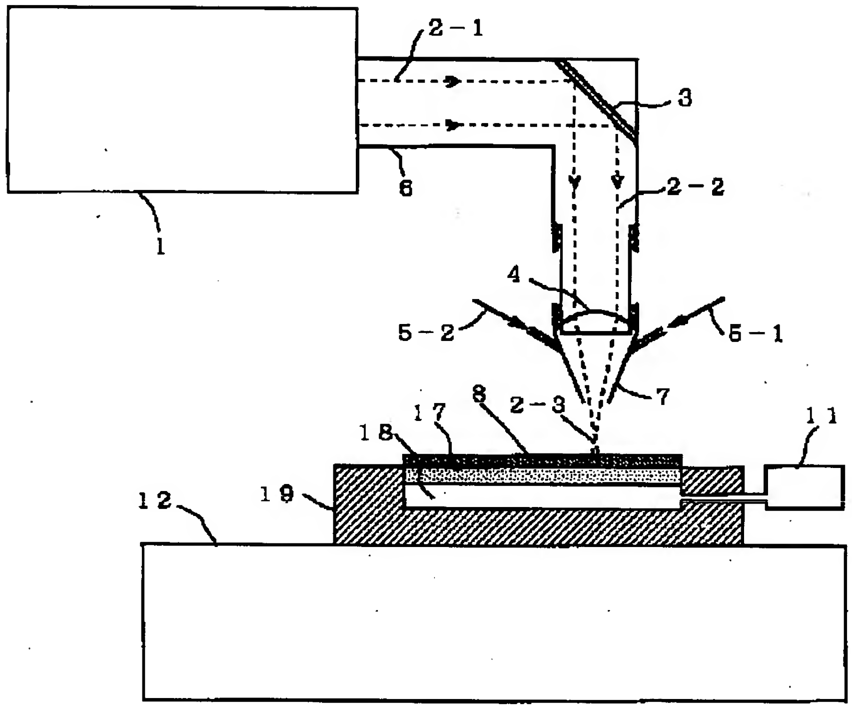
[Drawing 3]

Process 1	← S1
↓	
The process in which scribed lines are pre-engraved in the vicinities of the intersections of areas cut into a grid pattern, or at one end or the other end, or from one end to the other end, in the x direction of the nonmetallic-material substrate, along the CO_2 laser beam irradiation path.	← SC (Process C)
↓	
Process 2	← S2
↓	
Process 3	← S3
↓	
Process 4	← S4
↓	
Process 5	← S5
↓	
Process 6	← S6

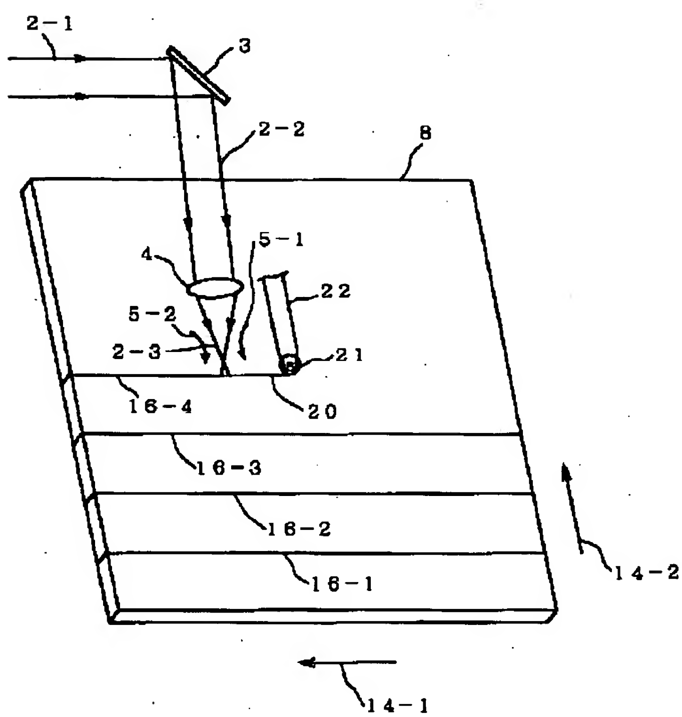
[Drawing 4]

Process 1	← S1
↓	
Process in which Process A and Process 2 are performed in conjunction.	← SD (Process D)
↓	
Process in which Process A and Process 2 are performed in conjunction.	← SE (Process E)
↓	
Process 4	← S4
↓	
Process 5	← S5
↓	
Process 6	← S6

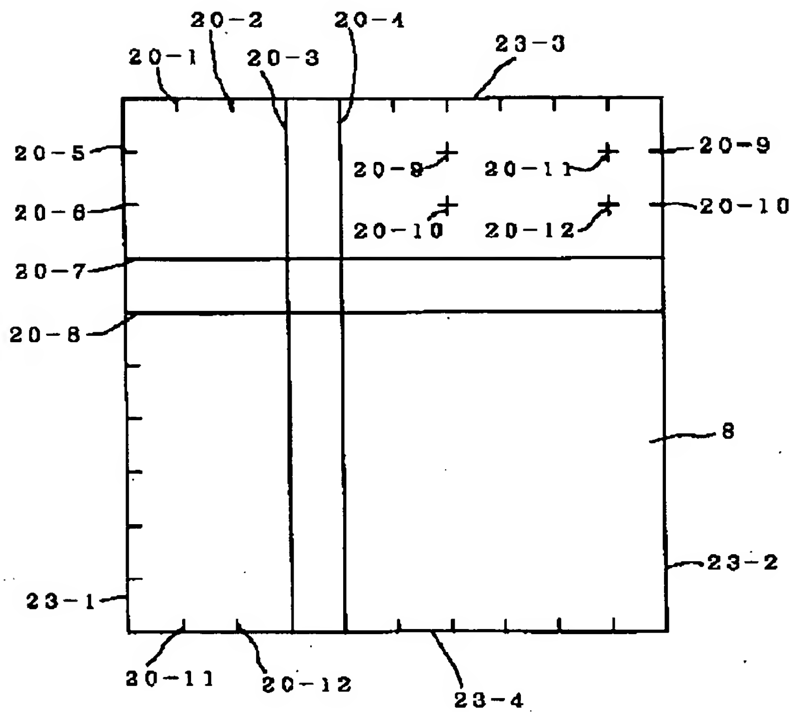
[Drawing 5]



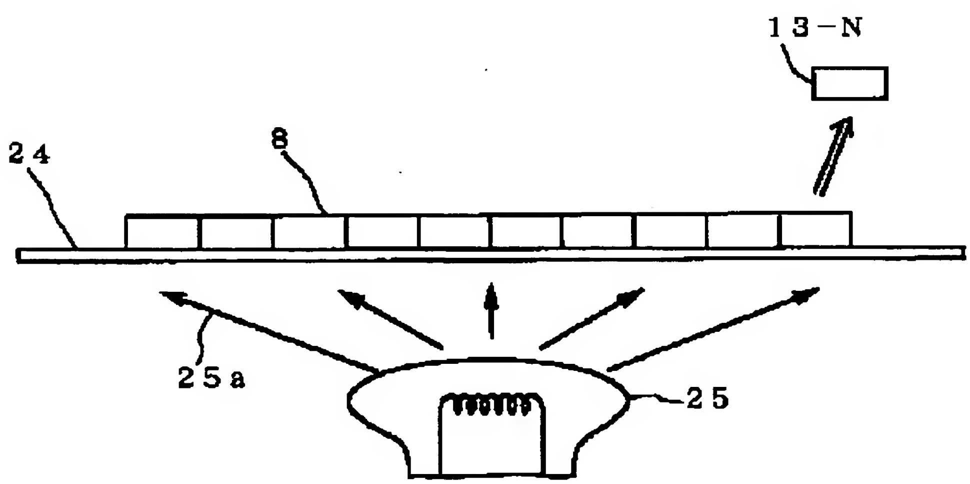
[Drawing 6]



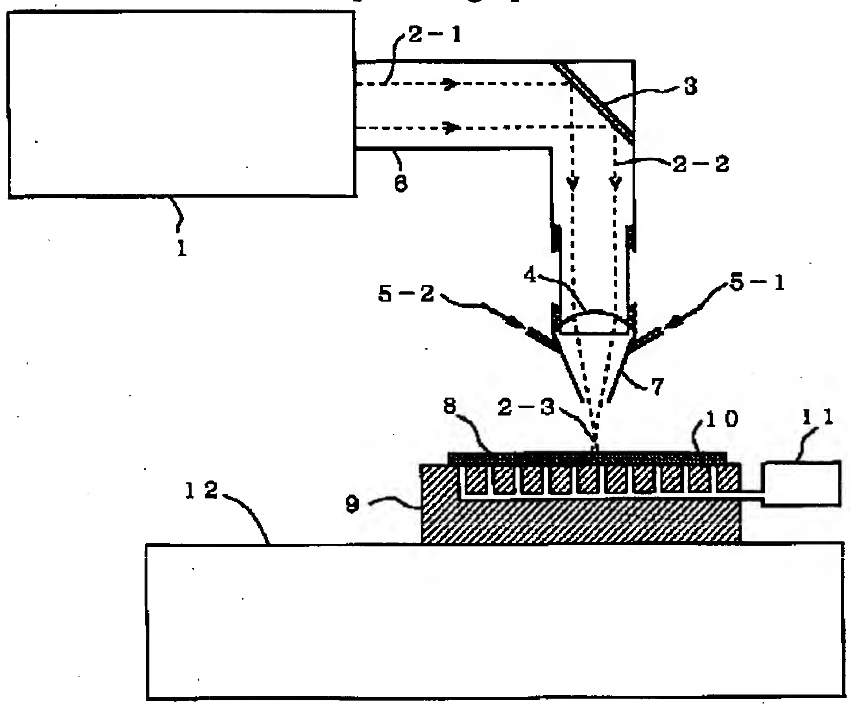
[Drawing 7]



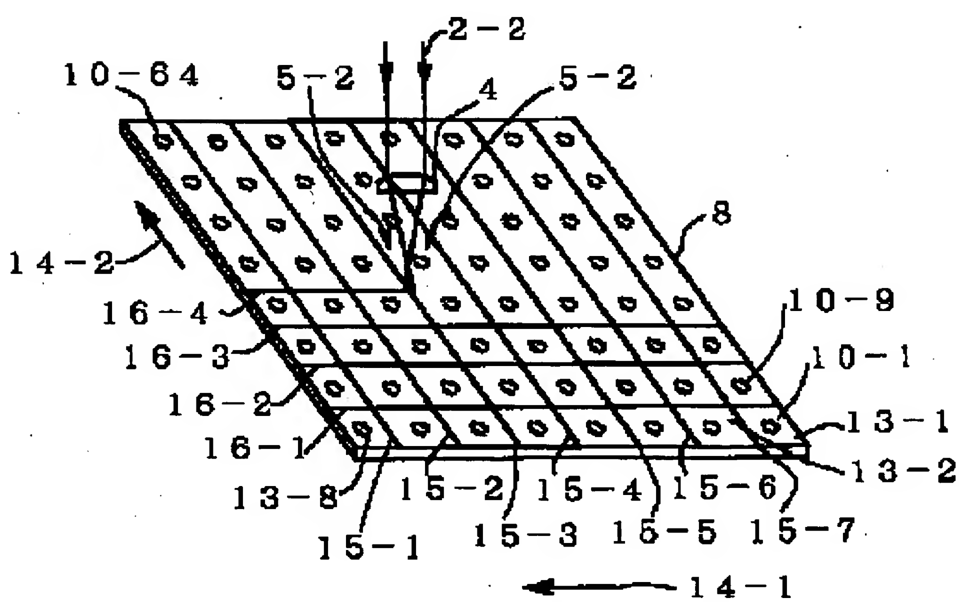
[Drawing 8]



[Drawing 9]



[Drawing 10]



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(71)出願人　000005120
日立電線株式会社
東京都千代田区大手町一丁目６番１号
(72)発明者　井本　克之
茨城県日立市日高町５丁目１番１号　日立電線株式会社オプトロシステム研究所内
(74)代理人　100068021
弁理士　絹谷　信雄

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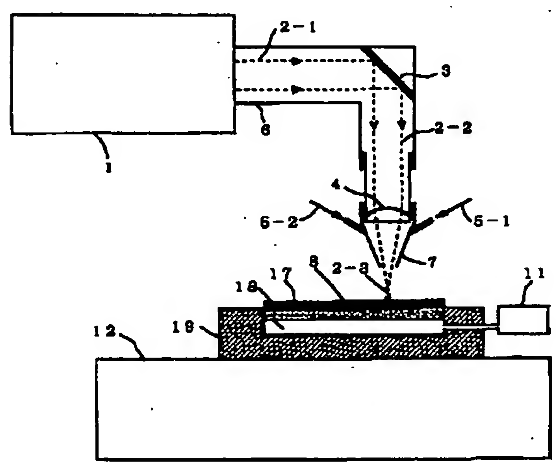
(54)【発明の名称】非金属材料基板の加工方法及びその装置

(57)【要約】
【課題】　レーザビームで非金属材料基板を割断する際に、その非金属材料基板をしっかり真空吸着できる非金属材料基板の加工方法及びその装置を提供する。
【解決手段】　非金属材料基板８をレーザビーム２－３で割断してチップ状の基板とする非金属材料基板の加工方法において、多孔質プレート板１７上に非金属材料基板８を置き、その多孔質プレート板８の下から真空排気して多孔質プレート板１７上に非金属材料基板８を真空吸着させながらレーザビーム２－３で割断するようにしたものである。



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【特許請求の範囲】

【請求項１】　非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工方法において、少なくとも５００℃の温度に耐える多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させながらレーザビームで割断することを特徴とする非金属材料基板の加工方法。

【請求項２】　非金属材料基板をレーザビームで割断してチップ状の基板とした後、その各チップを分離して取り出す非金属材料基板の加工方法において、多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させながらレーザビームで割断した後、その割断した非金属材料基板シートにＵＶ接着シートを貼り付け、真空吸着をブレークした後その非金属材料基板をＵＶ接着シートごと多孔質プレート板から分離し、その後ＵＶ接着シートにＵＶ光を照射してその接着力を弱めて各チップ状の基板をそれぞれ分離して取り出すことを特徴とする非金属材料基板の加工方法。

【請求項３】　非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工方法において、

移動装置上に設置された多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させる工程１；上記非金属材料基板上にレーザビームを照射しつつ上記移動装置を作動させて非金属材料基板をＸ軸方向に所望速度で移動させて非金属材料基板の一方端から他方端まで割断き裂を発生させる工程と、Ｙ軸方向に所望ピッチずらせて再びＸ軸方向に割断き裂を発生する工程とを、複数回繰り返す工程２；上記非金属材料基板を上記移動装置で９０°回転させ、再びレーザビームを非金属材料基板上に照射しつつ、移動装置を作動させて非金属材料基板をＹ軸方向に所望速度で移動させてその一方端から他方端まで割断き裂を発生させる工程と、Ｘ軸方向に所望ピッチずらせて再びＸ軸方向に割断き裂を発生する工程とを、複数回繰り返す工程３；上記Ｘ及びＹ軸方向に格子状の割断き裂の発生した非金属材料基板表面上にＵＶ接着シートを貼り付ける工程４；真空排気装置の真空ブレークを行ってＵＶ接着シート付き非金属材料基板を多孔質プレート板上から分離して搬送機構に移し搬送する工程５；ＵＶ接着シートにＵＶ光を照射してその接着シートの接着力を弱め、割断き裂されたチップ状の基板を分離して取り出す工程５；以上の６つの工程からなることを特徴とする非金属材料基板の加工方法。

【請求項４】　工程１と工程２間に、レーザビームの照射軌跡上の非金属材料基板のＸ軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割

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断する部分の交叉部近傍に予めけがき線を刻印しておく工程Ａを付加し、また第２の工程と第３の工程との間にレーザビームの照射軌跡上の非金属材料基板のＹ軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程Ｂを付加した請求項３記載の非金属材料基板の加工方法。

【請求項５】　工程１と工程２間に、レーザビームの照射軌跡上の非金属材料基板のＸ軸方向及びＹ軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程Ｃを付加した請求項３記載の非金属材料基板の加工方法。

【請求項６】　工程Ａと工程２を連動して行うようにする工程Ｄと、工程Ｂと工程３を連続して行うようにする工程Ｅにした請求項４記載の非金属材料基板の加工方法。

【請求項７】　レーザビームとして、CO_2 レーザビーム、ＣＯレーザビーム、ＹＡＧレーザビーム、ＹＡＧレーザビームの高調波レーザビーム、エキシマレーザビームを用いた請求項１～６いずれかに記載の非金属材料基板の加工方法。

【請求項８】　レーザビームに沿ってアシストガスを流すようにした請求項１～７いずれかに記載の非金属材料基板の加工方法。

【請求項９】　レーザビームは非金属材料基板上に幅Ｗ、長さＬの細長い線状ビームで照射されるようにした請求項１～８いずれかに記載の非金属材料基板の加工方法。

【請求項１０】　非金属材料基板上に照射されているレーザビームの直ぐ後方側を冷却しながら非金属材料基板を加工する請求項１～９いずれかに記載の非金属材料基板の加工方法。

【請求項１１】　非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工装置において、レーザビームは照射される移動装置上に、チップ状に割断する非金属材料基板を設置する多孔質プレート板を設け、その多孔質プレート板の下面に真空排気口を形成し、その真空排気口に真空排気装置を接続したことを特徴とする非金属材料基板の加工装置。

【請求項１２】　非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工装置において、

移動装置上に設置された多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させる第１の手段と、

非金属材料基板上にレーザビームを照射しつつ、移動装置を作動させて非金属材料基板をＸ軸方向に所望速度で移動させて非金属材料基板の一方端から他方端まで割断

き裂を発生させる工程と、Y軸方向に所望ピッチずらせて再びX軸方向に割断き裂を発生させる工程とを複数回繰り返す第2の手段と、
上記非金属材料基板を上記移動装置で90°回転させ、再びレーザビームを非金属材料基板上に照射しつつ、移動装置を作動させて非金属材料基板をY軸方向に所望速度で移動させてその一方端から他方端まで割断き裂を発生させる工程と、X軸方向に所望ピッチずらせて再びX軸方向に割断き裂を発生する工程とを、複数回繰り返す第3の手段と、
上記X及びY軸方向に格子状の割断き裂の発生した非金属材料基板表面上にUV接着シートを貼り付ける第4の手段と、
真空排気装置の真空ブレークを行ってUV接着シート付き非金属材料基板を多孔質プレート板上から分離して搬送機構に移し搬送する第5の手段と、
UV接着シートにUV光を照射してその接着シートの接着力を弱め、割断き裂されたチップ状の基板を分離して取り出す第6の手段とを備えたことを特徴とする非金属材料基板の加工装置。

【請求項13】　第1の手段と第2の手段間に、レーザビームの照射軌跡上の非金属材料基板のX軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段A）を付加し、また第2の手段と第3の手段との間にレーザビームの照射軌跡上の非金属材料基板のY軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段B）を付加した請求項12記載の非金属材料基板の加工装置。

【請求項14】　第1の手段と第2の手段間に、レーザビームの照射軌跡上の非金属材料基板のX軸方向及びY軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段C）を付加した請求項13記載の非金属材料基板の加工装置。

【請求項15】　手段Aと第2の手段を連動して行うようにする手段と、手段Bと第3の手段を連続して行うようにする手段を備えた請求項14記載の非金属材料基板の加工装置。

【請求項16】　レーザビームとして、CO_2レーザビーム、COレーザビーム、YAGレーザビーム、YAGレーザビームの高調波レーザビーム、エキシマレーザビームを用いた請求項11～15いずれかに記載の非金属材料基板の加工装置。

【請求項17】　多孔質プレート板として、セラミックスか金属製の多孔質プレート板を用いた請求項11～16いずれかに記載の非金属材料基板の加工装置。

【請求項18】　レーザビームに沿ってアシストガスを流すようにした請求項11～17いずれかに記載の非金属材料基板の加工装置。

【請求項19】　レーザビームは非金属材料基板上に幅W、長さLの細長い線状ビームで照射されるようにした請求項11～18いずれかに記載の非金属材料基板の加工装置。

【請求項20】　非金属材料基板上に照射されているレーザビームの直ぐ後方側を冷却しながら非金属材料基板を加工する請求項11～19いずれかに記載の非金属材料基板の加工装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、非金属材料基板をレーザビームで割断加工してチップとするための非金属材料基板の加工方法及びその装置に関するものである。

【0002】

【従来の技術】ガラス基板、セラミックス基板、絶縁膜付き半導体（Si、GaAs、InPなど）基板、サファイヤ基板、$LiNbO_3$や$LiTaO_3$などの結晶基板などの非金属基板を微少サイズのチップ状に精密分断加工する技術の要求が高まってきている。

【0003】特に、分断時にパーティクルが発生せず、ドライプロセスで数mm角サイズにチッピングを生ぜずに分断加工する技術が強く望まれている。

【0004】上記要求に対して、CO_2レーザビームを用いて非接触、ドライプロセスで割断する技術が注目されている。

【0005】図9は、従来のCO_2レーザービームを用いた非金属材料基板の加工装置の概略図を示したものである。

【0006】CO_2レーザ発振器1から出射されたCO_2レーザビーム（平行ビーム）2－1はフード6内を伝搬し、全反射ミラー3によって直角に曲げられて矢印2－2のごとく伝搬し、集光レンズ4に入射され、ここでビーム2－3は矢印のごとく集光され、そのビーム2－3が円錐形ガスノズル管7内を通って非金属材料基板8上に照射される。またアシストガス5－1及び5－2も上記ガスノズル管7を通って上記金属材料基板8上に吹き付けられる。

【0007】非金属材料基板8は、XYZθ移動装置（あるいはXYθ移動装置）12上のワークテーブル9上に真空吸着されている。

【0008】10は真空吸引穴であり、11は上記真空吸引穴10を通して基板8の裏面をワークテーブル9上に真空吸着するための真空排気装置である。

【0009】CO_2レーザービーム2－3は、X（あるいはY）方向に移動中の非金属材料基板8の一方の端から他方の端に向かって照射される。それによって基板8には熱応力によってき裂が発生され、そのき裂を進展させることによって割断により、基板8は分断される。

【0010】図10は非金属材料基板8を格子状に分断

し、チップ１３－１、１３－２、…を得る方法の模式図を示したものである。

【００１１】非金属材料基板８を、先ず、矢印１４－２のＹ方向に移動させつつ、き裂１５－１、１５－２、１５－３、…、１５－７を次々に発生させる。次に、基板８を９０°回転させた後、基板８を矢印１４－１方向に移動させつつ、き裂を１６－１、１６－２、１６－３、１６－４…のごとく発生させてチップ１３－１、１３－２…を得る方法である。

【００１２】各々のチップ１３－１、１３－２、１３－３、…の裏面には真空吸引穴１０－１、１０－２、１０－３、…１０－６４が設けられている。

【００１３】なお、CO_2レーザの代わりに、ＹＡＧレーザの第２高調波光、第３光調波光を用いた場合も同様の方法で割断加工が行われる。

【００１４】

【発明が解決しようとする課題】ところが従来のレーザを用いた割断加工方法及びその装置にはまだ次のような問題がある。

【００１５】（１）チップサイズが数ｍｍ角か、それより小さくなってくると、それぞれ分断するチップ面の裏面に設けた真空吸引穴１０も直径が数ｍｍか、それより小さくしないといけない。なぜならば、それぞれの分断したチップが割断加工時に吹き飛ばされないように、しっかりと真空吸着しておかなければならないからである。しかし、直径が１ｍｍかそれよりも小さくなると、真空吸引力が大幅に低下し、真空吸引が難しい。またワークテーブル上に上記真空吸引穴１０を１ｍｍ間隔で多数設けることが機械寸法精度（ワークテーブルの平坦性）の面からも難しい。

【００１６】（２）上記真空吸着力の弱さのために、割断加工中にき裂部分に隙間が発生してしまい、直交して格子状にき裂を発生させる際に、き裂を発生しにくくしたり、格子状の交叉部に不連続ばき裂が発生したりして四角形（あるいは長方形）のチップを寸法精度良く分割することが難しい。また最悪の場合には割断加工中にチップが飛び散ってしまうなどの問題点があった。

【００１７】（３）割断終了時に分断したそれぞれのチップを整列良く取り出して搬送することが難しい。

【００１８】そこで、本発明の目的は、上記課題を解決し、レーザビームで非金属材料基板を割断する際に、その非金属材料基板をしっかり真空吸着できる非金属材料基板の加工方法及びその装置を提供することにある。

【００１９】

【課題を解決するための手段】上記目的を達成するために、請求項１の発明は、非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工方法において、少なくとも５００℃の温度に耐える多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させながらレーザビームで割断するようにした非金属材料基板の加工方法である。

【００２０】請求項２の発明は、非金属材料基板をレーザビームで割断してチップ状の基板とした後、その各チップを分離して取り出す非金属材料基板の加工方法において、多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させながらレーザビームで割断した後、その割断した非金属材料基板シートにＵＶ接着シートを貼り付け、真空吸着をブレークした後その非金属材料基板をＵＶ接着シートごと多孔質プレート板から分離し、その後ＵＶ接着シートにＵＶ光を照射してその接着力を弱めて各チップ状の基板をそれぞれ分離して取り出すようにした非金属材料基板の加工方法である。

【００２１】請求項３の発明は、非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工方法において、移動装置上に設置された多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させる工程１；上記非金属材料基板上にレーザビームを照射しつつ上記移動装置を作動させて非金属材料基板をＸ軸方向に所望速度で移動させて非金属材料基板の一方端から他方端まで割断き裂を発生させる工程と、Ｙ軸方向に所望ピッチずらせて再びＸ軸方向に割断き裂を発生する工程とを、複数回繰り返す工程２；上記非金属材料基板を上記移動装置で９０°回転させ、再びレーザビームを非金属材料基板上に照射しつつ、移動装置を作動させて非金属材料基板をＹ軸方向に所望速度で移動させてその一方端から他方端まで割断き裂を発生させる工程と、Ｘ軸方向に所望ピッチずらせて再びＸ軸方向に割断き裂を発生する工程とを、複数回繰り返す工程３；上記Ｘ及びＹ軸方向に格子状の割断き裂の発生した非金属材料基板表面上にＵＶ接着シートを貼り付ける工程４；真空排気装置の真空ブレークを行ってＵＶ接着シート付き非金属材料基板を多孔質プレート板上から分離して搬送機構に移し搬送する工程５；ＵＶ接着シートにＵＶ光を照射してその接着シートの接着力を弱め、割断き裂されたチップ状の基板を分離して取り出す工程６；以上の６つの工程からなる非金属材料基板の加工方法である。

【００２２】請求項４の発明は、工程１と工程２間に、レーザビームの照射軌跡上の非金属材料基板のＸ軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程Ａを付加し、また工程２と工程３との間にレーザビームの照射軌跡上の非金属材料基板のＹ軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程Ｂを付加した請求項３記載

の非金属材料基板の加工方法である。

【0023】請求項5の発明は、工程1と工程2間に、レーザビームの照射軌跡上の非金属材料基板のX軸方向及びY軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程Cを付加した請求項3記載の非金属材料基板の加工方法である。

【0024】請求項6の発明は、工程Aと工程2を連動して行うようにする工程Dと、工程Bと工程3を連続して行うようにする工程Eにした請求項4記載の非金属材料基板の加工方法である。

【0025】請求項7の発明は、レーザビームとして、CO_2 レーザビーム、COレーザビーム、YAGレーザビーム、YAGレーザビームの高調波レーザビーム、エキシマレーザビームを用いた請求項1～6いずれかに記載の非金属材料基板の加工方法である。

【0026】請求項8の発明は、レーザビームに沿ってアシストガスを流すようにした請求項1～7いずれかに記載の非金属材料基板の加工方法である。

【0027】請求項9の発明は、レーザビームは非金属材料基板上に幅W、長さLの細長い線状ビームで照射されるようにした請求項1～8いずれかに記載の非金属材料基板の加工方法である。

【0028】請求項10の発明は、非金属材料基板上に照射されているレーザビームの直ぐ後方側を冷却しながら非金属材料基板を加工する請求項1～9いずれかに記載の非金属材料基板の加工方法である。

【0029】請求項11の発明は、非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工装置において、レーザビームは照射される移動装置上に、チップ状に割断する非金属材料基板を設置する多孔質プレート板を設け、その多孔質プレート板の下面に真空排気口を形成し、その真空排気口に真空排気装置を接続した非金属材料基板の加工装置である。

【0030】請求項12の発明は、非金属材料基板をレーザビームで割断してチップ状の基板とする非金属材料基板の加工装置において、移動装置上に設置された多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させる第1の手段と、非金属材料基板上にレーザビームを照射しつつ、移動装置を作動させて非金属材料基板をX軸方向に所望速度で移動させて非金属材料基板の一方端から他方端まで割断き裂を発生させる工程と、Y軸方向に所望ピッチずらせて再びX軸方向に割断き裂を発生させる工程とを複数回繰り返す第2の手段と、上記非金属材料基板を上記移動装置で90°回転させ、再びレーザビームを非金属材料基板上に照射しつつ、移動装置を作動させて非金属材料基板をY軸方向に所望速度で移動させてその一方端から他方端まで割断き裂を発生させる工程と、X軸方向に所望ピッチずらせて再びX軸方向に割断き裂を発生する工程とを、複数回繰り返す第3の手段と、上記X及びY軸方向に格子状の割断き裂の発生した非金属材料基板表面上にUV接着シートを貼り付ける第4の手段と、真空排気装置の真空ブレークを行ってUV接着シート付き非金属材料基板を多孔質プレート板上から分離して搬送機構に移し搬送する第5の手段と、UV接着シートにUV光を照射してその接着シートの接着力を弱め、割断き裂されたチップ状の基板を分離して取り出す第6の手段と、を備えた非金属材料基板の加工装置である。

【0031】請求項13の発明は、第1の手段と第2の手段間に、レーザビームの照射軌跡上の非金属材料基板のX軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段A）を付加し、また第2の手段と第3の手段との間にレーザビームの照射軌跡上の非金属材料基板のY軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段B）を付加した請求項12記載の非金属材料基板の加工装置である。

【0032】請求項14の発明は、第1の手段と第2の手段間に、レーザビームの照射軌跡上の非金属材料基板のX軸方向及びY軸方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく手段（手段C）を付加した請求項13記載の非金属材料基板の加工装置である。

【0033】請求項15の発明は、手段Aと第2の手段を連動して行うようにする手段と、手段Bと第3の手段を連続して行うようにする手段を備えた請求項14記載の非金属材料基板の加工装置である。

【0034】請求項16の発明は、レーザビームとして、CO_2 レーザビーム、COレーザビーム、YAGレーザビーム、YAGレーザビームの高調波レーザビーム、エキシマレーザビームを用いた請求項11～15いずれかに記載の非金属材料基板の加工装置である。

【0035】請求項17の発明は、多孔質プレート板として、セラミックスか金属製の多孔質プレート板を用いた請求項11～16いずれかに記載の非金属材料基板の加工装置である。

【0036】請求項18の発明は、レーザビームに沿ってアシストガスを流すようにした請求項11～17いずれかに記載の非金属材料基板の加工装置である。

【0037】請求項19の発明は、レーザビームは非金属材料基板上に幅W、長さLの細長い線状ビームで照射されるようにした請求項11～18いずれかに記載の非金属材料基板の加工装置である。

【0038】請求項20の発明は、非金属材料基板上に照射されているレーザビームの直ぐ後方側を冷却しなが

ら非金属材料基板を加工する請求項１１〜１９いずれかに記載の非金属材料基板の加工装置である。

【００３９】

【発明の実施の形態】以下、本発明の好適一実施の形態を添付図面に基づいて詳述する。

【００４０】先ず、図５により非金属材料基板の割断装置の構成を説明する。

【００４１】この図５において、図９で説明した符号と同一のものは同一の機能を有するものである。

【００４２】すなわち、CO_2レーザ発振器１から出射されたCO_2レーザビーム（平行ビーム）２−１はフード６内を伝搬し、全反射ミラー３によって直角に曲げられて矢印のごとく伝搬し、集光レンズ４に入射され、ここでビーム２−２は矢印のごとく集光され、そのビーム２−３が円錐形ガスノズル管７内を通って非金属材料基板８上に照射される。またアシストガス５−１及び５−２も上記ガスノズル管７を通って上記金属材料基板８上に吹き付けられる。

【００４３】非金属材料基板８は、ＸＹＺθ移動装置（あるいはＸＹθ移動装置）１２上のワークテーブル１９上に真空吸着されている。

【００４４】本発明においては、このワークテーブル１９を改良した点にある。

【００４５】すなわち、ワークテーブル１９には、少なくとも５００℃の温度に耐える多孔質プレート板１７が取り付けられ、その多孔質プレート板１７の上に非金属材料基板８が置かれ、また多孔質プレート板１７の下面のワークテーブル１９には真空排気口１８が設けられ、その真空排気口１８に真空排気装置１１が接続され、その真空排気口１８を、真空排気装置１１で真空排気することにより、非金属材料基板８の下面は多孔質プレート板１７、真空排気口１８を介して真空引きされて多孔質プレート板１７上に吸引されるように構成されている。

【００４６】CO_2レーザビーム２−３を用いた割断加工では、非金属材料基板８の裏面の瞬間的な温度上昇は５００℃以下であるので、多孔質プレート板１７の材質は、金属製、セラミックス製でも問題なく使用できる。

【００４７】この多孔質プレート板１７は、数μｍ〜１００μｍ程度の沢山の気孔穴を有する構造からなり、割断き裂によって１ｍｍ角程度のチップに分断する場合でも十分に真空吸着して非金属材料基板８を多孔質プレート板１７上に固持することができる。

【００４８】また多孔質プレート板１７の表面は、従来の真空吸引穴１０を多数設けたワークテーブル９の表面に比してはるかに平滑な表面であるので、非金属材料基板８の裏面が平滑でなくても十分に真空吸着することができる。

【００４９】さて、図１は本発明の非金属材料基板の割断加工方法の第１の実施の形態を示したもので、この割断加工方法は、６つの工程からなる。

【００５０】非金属材料基板としては、ガラス、セラミックス、絶縁膜付き半導体（Ｓｉ、ＧａＡｓ、ＩｎＰ、等）、結晶（サファイア、$LiNbO_3$、$LiTaO_3$、等）を用いることができる。この非金属材料基板を、０．数ｍｍ角程度の小チップから数ｍｍ角、あるいは数１０ｍｍ角の大チップにまで割断により分割する方法である。

【００５１】工程１；先ず工程１（Ｓ１）において、ＸＹＺθ方向に電気駆動に移動できる移動装置上に設置された多孔質プレート板上に非金属材料基板を置く。この多孔質プレート板は、金属製、セラミックス製等のものが使える。多孔質プレート板は、数μｍから１００μｍ程度の多数の気孔穴を有するプレート板であり、この多孔質プレート板の下から真空排気する機構を設けておけば、非金属材料基板は多孔質プレート板上に真空排気され、割断加工時にもアシストス吹き付けで吹き飛ぶことがない。また割断した微少サイズチップ（０．数ｍｍ角）も十分真空吸着された状態で多孔質プレート板上に吸着固定される。

【００５２】工程２；次に工程２（Ｓ２）において、真空吸着されている非金属材料基板上にアシストガスを吹き付けながら、かつ移動装置を移動させ移動装置上の非金属材料基板をＸ方向に所望速度で移動させつつ、CO_2レーザビームを非金属材料基板上の一方端から他方端まで照射する。これにより、非金属材料基板の一方端から亀裂を発生させ、他方端にまでそれを進展させる。同様の操作を非金属材料基板をＹ方向に所望ピッチずらせて再びＸ方向に割断き裂を発生させる。さらに上記操作を複数回繰り返すことにより、非金属材料基板のＹ方向に所望のピッチで割断き裂を基板の一方端から他方端まで形成する。

【００５３】工程３；次に工程３（Ｓ３）において、上記基板を移動装置で９０°回転させ、再びアシストガスを吹き付けながらCO_2レーザビームを非金属材料基板上に照射しつつ移動装置を作動させて非金属材料基板をＹ方向に所望速度で移動させて、一方端から他方端まで割断き裂を発生させる。そして再びＸ方向に所望ピッチずらせてＹ方向に割断き裂を発生させる工程を複数回繰り返す。

【００５４】以上のような操作により、非金属材料基板上にＸＹ格子状に割断き裂を発生させる。

【００５５】上記工程２及び３においては、レーザ発振器は波長が１０．６μｍのCO_2レーザを用いるが、これ以外に非金属材料基板に吸収されやすい波長の光源として、ＣＯレーザ、ＹＡＧレーザ、ＹＡＧレーザの高調波レーザ、エキシマレーザ等を用いることができる。

【００５６】次に工程３で分断した微少サイズの多数のチップを配列を乱さずに一体的に取り出して搬送し、最後にそれぞれのチップを分離して取り出す工程について説明する。

【００５７】工程４；先ず工程４（Ｓ４）において、工程３で割断き裂の発生した非金属材料基板を真空吸着した状態で、その基板表面にＵＶ接着シートを貼り付ける。このＵＶ接着シートは、例えばリンテック（株）製のダイシングテープを用いる。このテープはポリオレフィン材のシートの貼り付け面に接着層が形成されており、上記基板表面上に貼り付けることができる。

【００５８】工程５；次に工程５（Ｓ５）において、真空排気装置の真空をブレークしてＵＶ接着シート付き非金属材料基板を多孔質プレート基板上から分離して搬送機構に移し搬送する。各々のチップはＵＶ接着シートに貼り付けられているので、搬送中にはがれ落ちてバラバラになることがない。

【００５９】工程６；最後の工程６（Ｓ６）において、ＵＶ接着シートの反対面（非金属材料基板が貼り付けられていない面）側からＵＶ光を照射する。このＵＶ光照射により、上記ＵＶ接着シートの粘着力が大幅に低下（例えば３００ｍＮ／２５ｍｍ□の粘着力がＵＶ光照射によって５０ｍＮ／２５ｍｍ□の粘着力に低下）し、割断き裂されたそれぞれのチップが分離され、容易に上記ＵＶ接着シート上から取り出すことができる。そしてそれぞれのチップの電気的あるいは光学的チップ毎に評価し、デバイスや装置に実装することができる。

【００６０】以上のように、レーザ割断加工中にチップが吹き飛んだり、き裂部分に不要な隙間が発生することもなく、また非常に微少チップサイズのものでも十分に真空吸着して位置保持をすることができ、さらに、割断したチップを取り出す際にバラバラに分離してチップの基板上での位置など判らなくなることなどがなく、割断き裂を発生させた状態のまま加工装置から取り出して搬送することができ、そして最後にそれぞれのチップをそのままの状態で試験、検査してそれぞれのチップを取り出すこともできるし、またそれぞれのチップを取り出してから試験、検査することもできる。

【００６１】図２は、本発明の非金属材料基板の割断加工方法の第２の実施の形態を示したものである。

【００６２】第２の実施の形態では、図１に示した第１の実施の形態の工程１と工程２の間に工程Ａを設け、また工程２と工程３の間に工程Ｂを設けたものである。

【００６３】上記工程Ａは、CO_2 レーザビームの照射軌跡上の非金属材料基板のＸ方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程である。

【００６４】また工程Ｂは、CO_2 レーザビームの照射軌跡上の非金属材料基板のＹ方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程である。

【００６５】上記けがき線の刻印方法としては、従来の種々の方法、例えば、レーザ（ＹＡＧレーザ、エキシマレーザなど）照射によってけがき線を形成する方法、ダイヤモンドや超硬カッターを用いてけがき線を形成する方法、超音波振動機を用いてけがき線を形成する方法、先端が尖った金属製のヤスリ、ハリなどでけがき線を形成する方法などを用いることができる。

【００６６】このように予めレーザビームの軌跡線にけがき線を入れておけば、き裂の促進、き裂の直進性、交叉部の直角性などを改善することができる。

【００６７】図３は本発明の非金属材料基板の割断方法の第３の実施の形態を示したものである。

【００６８】第３の実施の形態においては、図１に示した第１の実施の形態の工程１と工程２との間に工程Ｃを設けたものである。

【００６９】この工程Ｃは、CO_2 レーザビームの照射軌跡上の非金属材料基板のＸ方向及びＹ方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程である。

【００７０】図４は本発明の非金属材料基板の割断方法の第４の実施の形態を示したものである。

【００７１】第４の実施の形態は、図２に示した第２の実施の形態の工程Ａと工程２とを連動して行う工程としたこと（工程Ｄ）と、工程Ｂと工程３を連動して行う工程としたこと（工程Ｅ）にある。

【００７２】図６は、本発明の非金属材料基板の加工方法の具体例を示したものである。

【００７３】この加工方法は、図４で説明した第４の実施の形態の工程Ｄの具体例を示したものである。

【００７４】すなわち、CO_2 レーザビームの照射軌跡上にけがき線を刻印しながらそのけがき線上にCO_2 レーザビームを照射してき裂を発生させつつ割断する方法である。

【００７５】けがき線２０は、この例では先端２１が回転式ダイヤモンドカッターで構成されたけがき線刻印部品２２をCO_2 レーザビームの前に設け、けがき線２０を刻印しながら、その後で上記けがき線２０上にCO_2 レーザビーム２－３を照射してき裂を発生させ、そのき裂を進展させて割断させるようにした方法である。

【００７６】図７は非金属材料基板８上へ予めけがき線を刻印した実施の形態を示したものである。

【００７７】非金属材料基板８の一端側２３－１（あるいは２３－３）に２０－５、２０－６…（あるいは２０－１、２０－２…）のごとくけがき線を刻印しておくか、または他方端側２３－２（あるいは２３－４）に２０－９、２０－１０…（あるいは２０－１１、２０－１１、…のごとくけがき線を刻印しておくか、あるいは一方端２３－１（あるいは２３－３）から他方端２３－２（あるいは２３－４）は連続的なけがき線を２０－７、２０－８…（あるいは２０－３、２０－４、…）のごと

く予め刻印しておくか、さらには格子状の交叉部近傍に２０－９、２０－１０、２０－１１、２０－１２、…のごとくけがき線を刻印しておいてもよい。

【００７８】図８は、本発明の非金属材料基板を図５の装置で、割断・き裂を発生させた上記基板を多孔質プレート板１７から取り出してＵＶ接着シート２４付き非金属材料基板８を搬送させ、上記ＵＶ接着シート２４の裏面側からＵＶ光源２５からＵＶ光２５ａを照射することによって接着層の粘着力を弱め、各々のチップ１３－１、１３－２、…１３－ＮをＵＶ接着シート２４から分離して取り出すようにしたものである。

【００７９】なお本発明に用いる非金属材料基板８の表面、裏面あるいは基板の中に、ＩＣ、ＬＳＩ等の電気回路、抵抗、インダクタンス、コンデンサ等の素子、電気配線パターン、あるいは光回路や光配線パターンが形成されてもよい。またレーザ照射面は、上記非金属材料基板の表面側、あるいは裏面側のどちら側でもよい。また非金属材料基板の形状は、四角形、円形、楕円形などのあらゆる形状のものであってもよい。レーザビーム２－３の非金属材料基板８上への照射形状は、好ましくは幅が１ｍｍ以下で、長さが１０ｍｍ以上の線状ビームや楕円ビームなどがよいが、ほぼ円形状ビームであってもよい。また非金属材料基板８上へのレーザビーム照射部の後方側を局部的に急冷するようにしてもよい。その急冷方法としては、冷媒ガスを吹き付ける方法が好ましい。

【００８０】

【発明の効果】以上要するに本発明によれば、次のような効果を奏する。

【００８１】(1) 基板裏面全体が一様に、かつ非常に強く真空吸着されているので、微少なサイズのチップに割断加工時に、割断したチップがアシストガスで引き飛んだり、チップとチップとの間に隙間が生じても割断加工寸法精度が低下することがない。

【００８２】(2) 割断終了時に、割断した基板形状をそのまま保った状態、すなわち、それぞれのチップがバラバラにならないようにＵＶ接着シートを基板表面に貼り付けて別の場所に搬送することができる。そして搬送してきた割断された基板上のそれぞれのチップの電気的あるいは光学的特性をチップを分離しない状態で評価することもできるし、またＵＶ光源を上記ＵＶ接着シートに照射してそれぞれのチップを分離し、上記のように電気的あるいは光学的特性を評価することができる。

【００８３】(3) 多孔質プレート板は非常な平滑な表面をしているので、割断したチップがｍｍサイズの微少なものでも割断加工中にチップが吹き飛ばされることはなく多孔質プレート板上に真空吸着させることができる。

【００８４】(4) 割断した基板ごと加工装置から取り出して搬送することができるので、トータルスループット時間を短くすることができる。すなわち、割断した後に、それぞれのチップを加工装置から１個ずつ取り出すのに比し、大幅な時間短縮を図ることができる。

【００８５】(5) また割断した基板ごと加工装置から取り出し、その基板上で、それぞれのチップ表面パターンの検査、電気的あるいは光学的特性の評価ができ、良品のみを分離することができるので、上記工程でも大幅な時間短縮を図ることができ、結果的に低コストでチップを生産することができるようになる。

【００８６】(6) 多孔質プレート板を使用しているので、任意サイズのチップを割断加工する際にも一つの多孔質プレート板を汎用的に使うことができ、製造装置コスト、試算コストを安くすることができる。

【図面の簡単な説明】

【図１】本発明の加工方法の第１の実施の形態を示す図である。

【図２】本発明の加工方法の第２の実施の形態を示す図である。

【図３】本発明の加工方法の第３の実施の形態を示す図である。

【図４】本発明の加工方法の第４の実施の形態を示す図である。

【図５】本発明の加工装置の実施の形態を示す図である。

【図６】本発明の第４の実施の形態の工程Ｄの具体例を示す概略斜視図である。

【図７】本発明の加工方法による非金属材料基板へ、予めけがき線を刻印する例を示す図である。

【図８】本発明の割断加工した非金属材料基板の保持方法及び搬送手段並びにチップの分離方法を示す図である。

【図９】従来の加工装置を示す図である

【図１０】従来の加工方法を示す図である。

【符号の説明】

２－３　レーザビーム

８　非金属材料基板

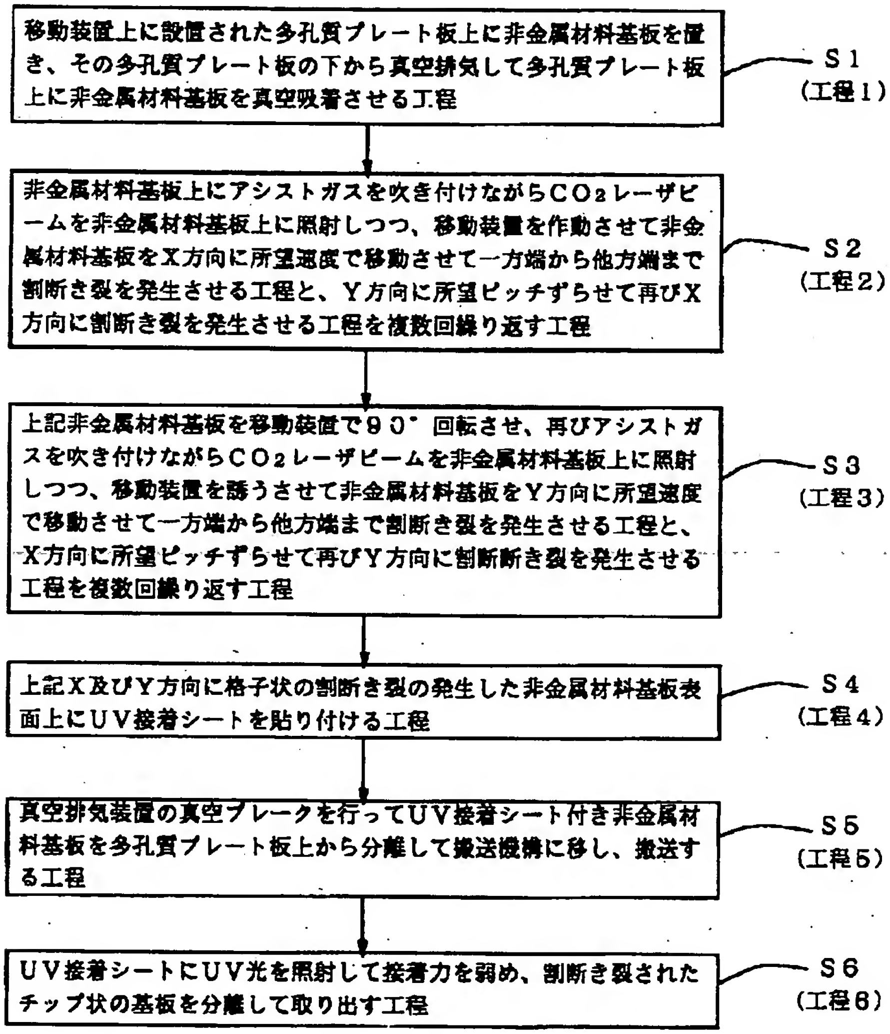
１１　真空排気装置

１７　多孔質プレート板

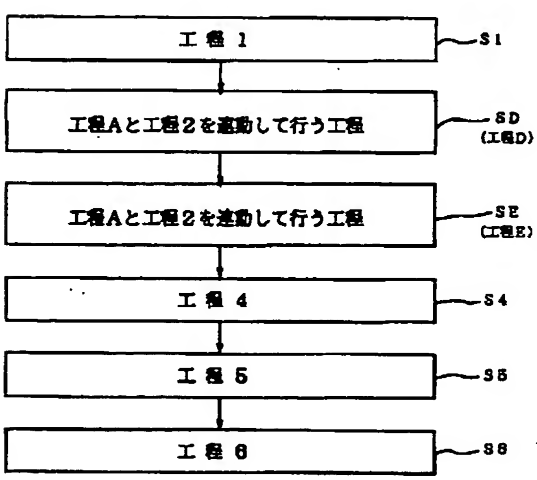
１８　真空排気口

１９　移動装置

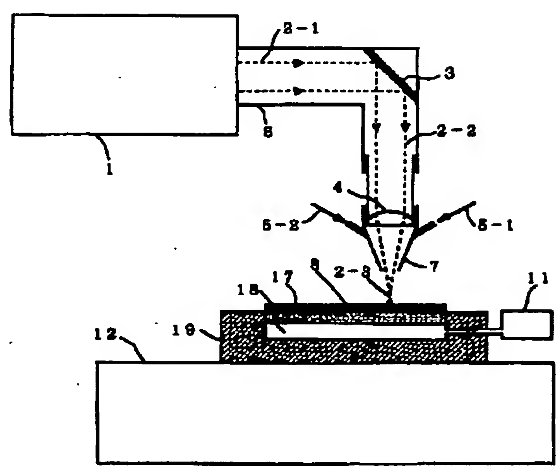
【図1】


移動装置上に設置された多孔質プレート板上に非金属材料基板を置き、その多孔質プレート板の下から真空排気して多孔質プレート板上に非金属材料基板を真空吸着させる工程
S1
(工程1)
非金属材料基板上にアシストガスを吹き付けながらCO_2レーザビームを非金属材料基板上に照射しつつ、移動装置を作動させて非金属材料基板をX方向に所望速度で移動させて一方端から他方端まで割断き裂を発生させる工程と、Y方向に所望ピッチずらせて再びX方向に割断き裂を発生させる工程を複数回繰り返す工程
S2
(工程2)
上記非金属材料基板を移動装置で90°回転させ、再びアシストガスを吹き付けながらCO_2レーザビームを非金属材料基板上に照射しつつ、移動装置を誘うさせて非金属材料基板をY方向に所望速度で移動させて一方端から他方端まで割断き裂を発生させる工程と、X方向に所望ピッチずらせて再びY方向に割断断き裂を発生させる工程を複数回繰り返す工程
S3
(工程3)
上記X及びY方向に格子状の割断き裂の発生した非金属材料基板表面上にUV接着シートを貼り付ける工程
S4
(工程4)
真空排気装置の真空ブレークを行ってUV接着シート付き非金属材料基板を多孔質プレート板上から分離して搬送機構に移し、搬送する工程
S5
(工程5)
UV接着シートにUV光を照射して接着力を弱め、割断き裂されたチップ状の基板を分離して取り出す工程
S6
(工程6)

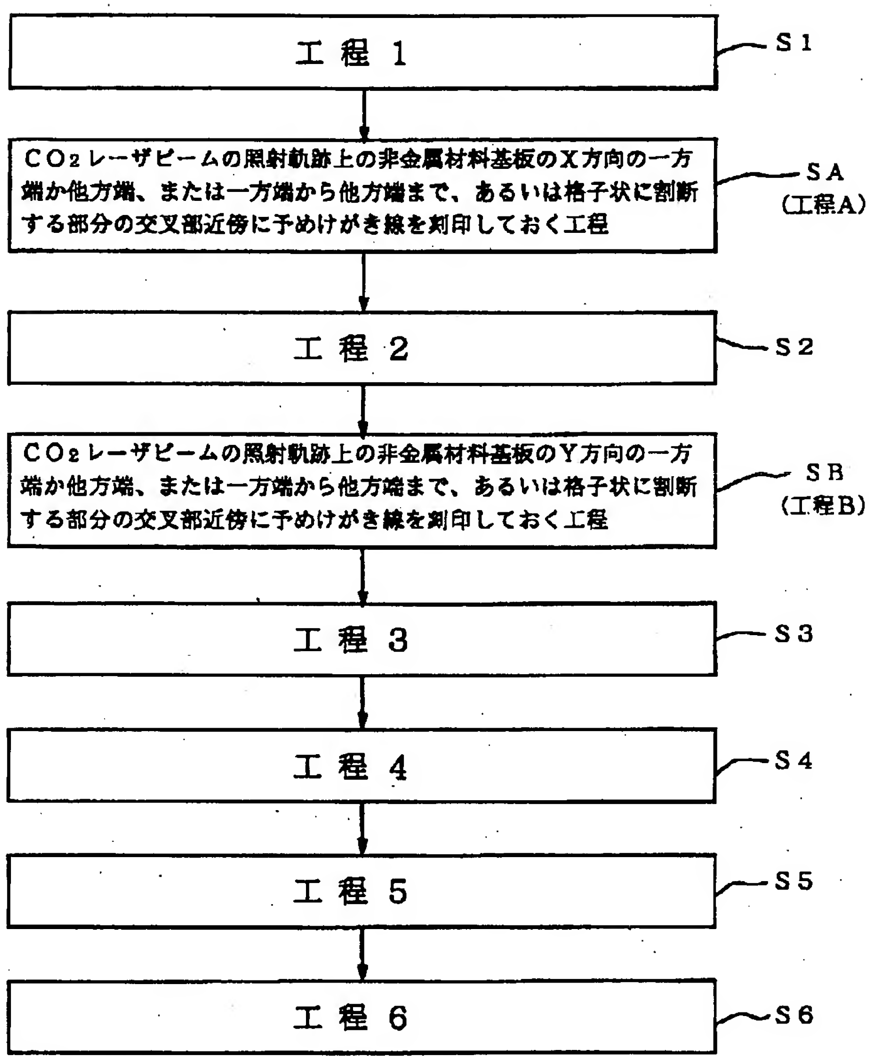
【図4】


工程1
S1
工程Aと工程2を連動して行う工程
SD
(工程D)
工程Aと工程2を連動して行う工程
SE
(工程E)
工程4
S4
工程5
S5
工程6
S6

【図5】

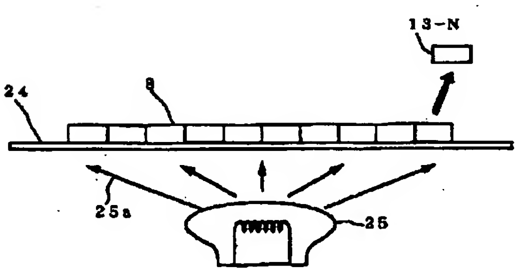

2-1
3
8
2-2
1
4
5-2
5-1
7
18
17
6
2-3
11
12
19

【図２】



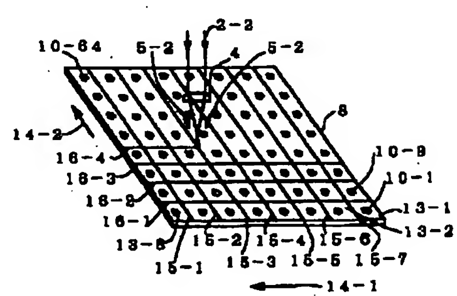
工 程 １
S１
CO2レーザビームの照射軌跡上の非金属材料基板のX方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程
SA
(工程A)
工 程 ２
S２
CO2レーザビームの照射軌跡上の非金属材料基板のY方向の一方端か他方端、または一方端から他方端まで、あるいは格子状に割断する部分の交叉部近傍に予めけがき線を刻印しておく工程
SB
(工程B)
工 程 ３
S３
工 程 ４
S４
工 程 ５
S５
工 程 ６
S６

【図８】



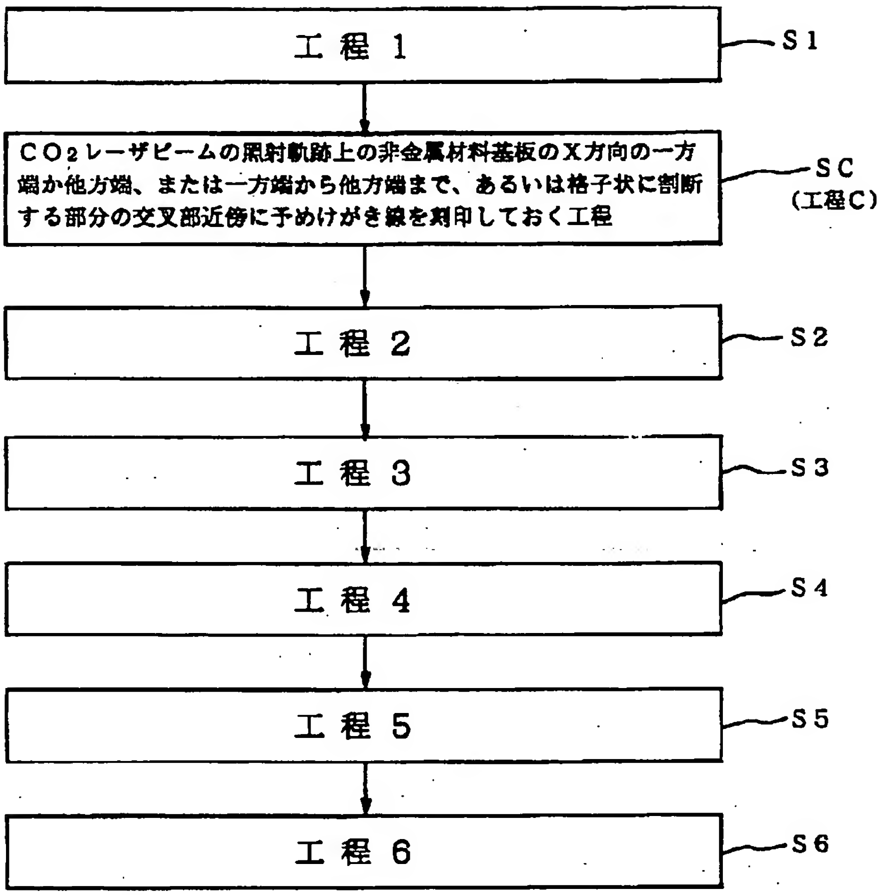
13−N
24
8
25a
25

【図１０】

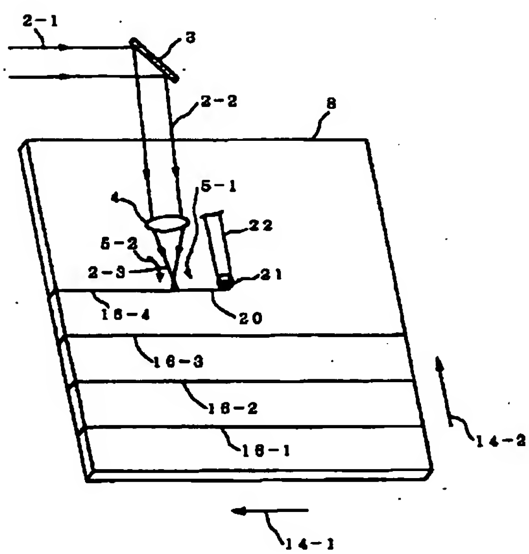


10−64
5−2
2−2
4
5−2
8
14−2
16−4
16−3
16−2
16−1
10−9
10−1
13−1
13−2
13−8
15−1
15−2
15−3
15−4
15−5
15−6
15−7
14−1

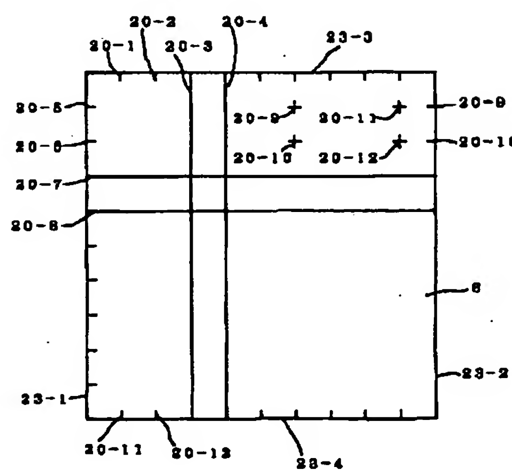
【図３】


工 程 1
S 1
CO2レーザビームの照射軌跡上の非金属材料基板のX方向の一方
端か他方端、または一方端から他方端まで、あるいは格子状に割断
する部分の交叉部近傍に予めけがき線を刻印しておく工程
S C
(工程C)
工 程 2
S 2
工 程 3
S 3
工 程 4
S 4
工 程 5
S 5
工 程 6
S 6

【図６】


2-1
3
2-2
8
5-1
4
22
5-2
2-3
21
16-4
20
16-3
16-2
16-1
14-2
14-1

【図７】


20-2
20-4
20-1
20-3
23-3
20-5
20-9
20-11
20-9
20-6
20-10
20-12
20-10
20-7
20-8
8
23-2
23-1
20-11
20-12
23-4

【図９】